

Battery charger regulator with fully controlled return 15 V/5 A in uninterruptible power supply

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ABSTRACT

Fully controlled rectifier and BCR. The battery charge regulator (BCR) is the most important unit of an uninterruptible power supply (UPS) device. The BCR uses a 15 V/5 A transformer to lower the voltage so as not to overload the BCR components. Full control using four thyristors serves to supply voltage to the BCR, while the BCR serves to regulate battery charging. Forcing the battery to be charged at a constant voltage with the same current results in shorter battery life. Battery charging through the BCR is set to match the battery voltage, then allowing the BCR to control it by adjusting the phase voltage to 13.5 V for high voltage discharge (HVD) and 10.5 V for low voltage discharge (LVD). By using an IC Regulator combined with a relay as a voltage breaker for a fully charged battery, it will automatically disconnect to avoid overcharging the battery. Based on the performance test results of a fully controlled rectifier system using thyristors and BCR on a 12 V/5 Ah battery, the output voltage is as a fully controlled 12 V rectifier, the BCR switch can charge the internal battery in minutes with a current that varies between 2.1 A to 0.1 A.

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1. INTRODUCTION

Uninterruptible power supply (UPS) is an electric power system that is able to provide power quickly when electronic devices need it, at the right time to avoid the effects of data loss [1]. One electronic device that is widely used and requires that it is always connected to a power supply is a computer [2], [3]. The continuity of the electricity source which is usually sourced from PLN to computer equipment cannot be relied upon because it is often interrupted and unstable, so uninterruptible power supply (UPS) is needed [3], [4]. The main component supporting the work of the UPS is the rectifier system as a battery charger, allowing the inverter to provide AC power in the event of a power outage from PLN [5]–[8]. When charging the electric current to the UPS, it is necessary to control it so that the voltage and current can match the increase in the battery voltage in the UPS [9].

In charging the battery, the battery charger control circuit or also called BCR is used to control the battery charging process [10]. The goal in designing a fully controlled rectifier and BCR is to produce a control variable voltage and current that corresponds to the increase in battery voltage [11]. By adjusting the supply voltage of the battery during charging as a function of the battery voltage it controls the amount of charging current [12]. Due to these limitations, a silicon controller rectifier (SCR) is used, namely a thyristor where the gate can be adjusted by changing the angle α to adjust the voltage. So that the charging of the

battery is under control and can maintain the battery voltage level under normal conditions so that charging the battery becomes fast and safe, that is by using a control charger.

One of the problems that often occurs in electronic devices is damage to the battery. When overcharging, under voltage and overheated battery temperatures often cause damage to the battery. Therefore we need a battery charger regulator with fully controlled return 15 V / 5 A in uninterrupted power supply as the topic of this research that is, when the battery is fully charged, the control system issues a command to interrupt the battery charging circuit [13], this is different from previous research which only used the battery charging control system at power plants [14], so that by using this fully controlled and more updated battery charge control system, it is able to improve battery life.

2. METHOD

Uninterruptible power supply (UPS) is a backup power system that is used when the main power supply is interrupted. An uninterruptible power supply can be used as a backup power source at home in the event of a power outage caused by a PLN [15]. UPS can function to protect electronic equipment that is sensitive to unstable currents and voltages [16]. Inside the UPS there is an inverter circuit that is useful for converting DC voltage into AC. So that this tool can be used in electronic equipment that requires an AC power source such as televisions, lights, and especially computers [17]. Battery charge controller is an electronic circuit that controls the process of charging a battery or battery bank (battery bank). The DC voltage of the thyristor or rectifier circuit varies from 12 volts and more [18]. To regulate that the battery voltage does not exceed the tolerance limit, a regulator is used.

In addition, over-voltage entering the battery is also prevented by the regulator [19]. When the battery is fully charged, the DC voltage supply will be cut off, thereby reducing damage, namely long battery life. Controlling the battery charging process by opening and closing the direct current flow from the rectifier to the battery is the basic function of a battery charge controller [20]. An example of the application of the BCR system is the installation of BCR on a UPS that uses a battery as a power source for electronic equipment [21]. Thyristors are used as rectifiers, thyristors are semiconductor-based electronic devices that can regulate large currents and voltages [22]. The higher the voltage rises, the higher the current, and conversely, the lower the voltage is applied, the less current will flow to avoid surges. It is a characteristic of the thyristor that the trigger current initially flows through the gate of the thyristor when the trigger angle is set. By doing this, it takes time to delay the incoming load current so that the firing angle current completes the firing angle first [23]. The AC voltage from this process is limited so that it is reduced and processed by the thyristor as a DC output [24]. The output waveform corresponding to the thyristor ignition angle is shown in Figure 1.

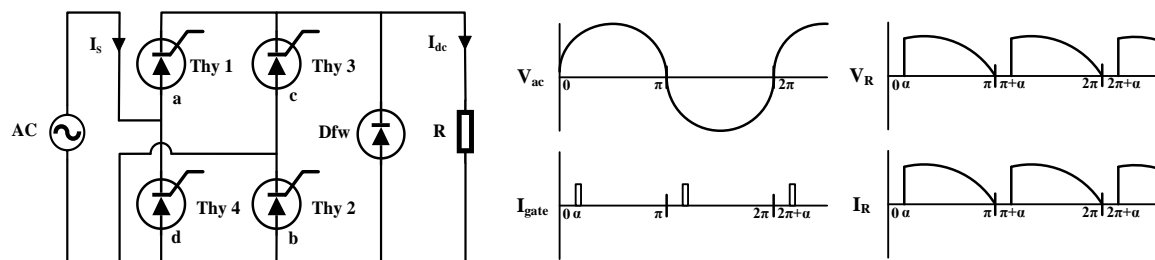


Figure 1. Thyristor ignition angle

Figure 1 is a controlled full-wave rectifier with a resistive load. The main working process of this circuit is the same as that of an uncontrolled full-wave rectifier. The difference is that this circuit can be triggered at a certain angle [25]. When the voltage level between the anode and cathode is increased to a certain point, the reverse voltage across J2 is cut off (transparent) and the pressure at that moment is called the forward voltage (VBO). Since J1 and J3 are still forward biased, current flows from the large anode to the cathode across the three junctions J1, J2, and J3. At this time, the SCR is conducting or is in a conducting state. the voltage between the anode and cathode is very small (± 1 volt) or falls far beyond. A, the anode-cathode current depends on the load current (load impedance) [26]. The anode-cathode current must be greater than the reverse current I_L so that the current continues to flow through the junction, namely H. The SCR returns to the off state when the anode-cathode voltage drops [27]. When the cathode is more positive

than the anode, the J2 junction is forward biased, and J1 and J3 are reverse biased. The characteristics of the thyristor can be seen in Figure 2.

In Figure 2 the breakover voltage V_b , which if the forward SCR voltage reaches this point, the SCR will be ON. Even more important is the current I_g which can cause the voltage V_b to drop to be smaller. The figure shows some I_g currents and their correlation to the breakover voltage. On the SCR datasheet, this gate trigger current is often written in IGT (gate trigger current) notation. The figure also shows the I_h current, namely the holding current that keeps the SCR ON. As already explained, the SCR is conductive, it remains conductive even though the gate current is removed, that is, a power failure on the SCR changes the state from conduction (ON) to non-conducting (OFF) [19], [28]. Substitution or substitution is the process of turning off the SCR. Type of replacement process, for example:

- The natural switch occurs when the SCR is powered by AC mains [29]
- Forced switching is carried out when the SCR is given a current source in the same direction, for example through a supply release or a short circuit between A and K for a moment [30]

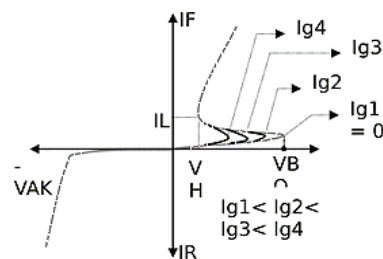


Figure 2. Thyristor characteristics

3. RESULTS AND DISCUSSION

3.1. Circuit design

The electrical design is divided into several parts, namely the design of components in the BCR circuit, several things that will be tested in this circuit, namely testing of thyristors, IC regulators, relays, and batteries. From several tests of these components, it is necessary to design a rectifier and voltage regulator. The following is a schematic diagram of the electrical design shown in Figure 3. In the rectifier circuit, four SCRs will be used, namely thyristors with the bridge method which will produce a direct voltage output with a voltage value that can be adjusted according to the ignition gate. The voltage waveform generated by the rectifier still has ripple or ripple and is not perfect, therefore after the rectifier circuit, electrolytic capacitor will be used as an output wave filter. The following is a schematic diagram of the regulator shown in Figure 4. Figure 4 is a voltage regulator circuit that regulates the maximum output voltage of 12 volts DC, this component can be called a stabilizer which is useful so that the voltage remains constant when charging the battery. Figure 5 is an overall schematic diagram using a rectifier, voltage regulator, and automatic cut-off arrangement.

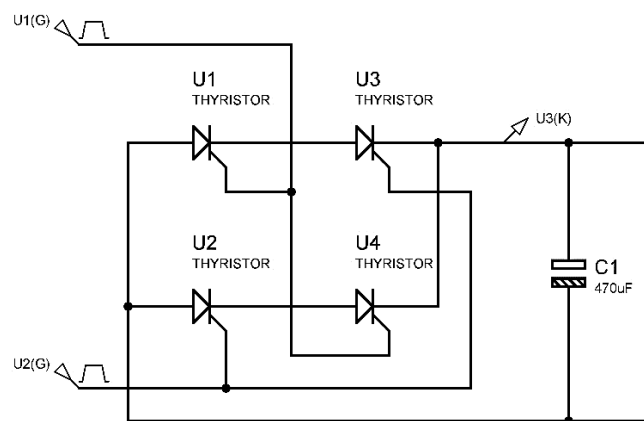


Figure 3. Schematic diagram of the rectifier

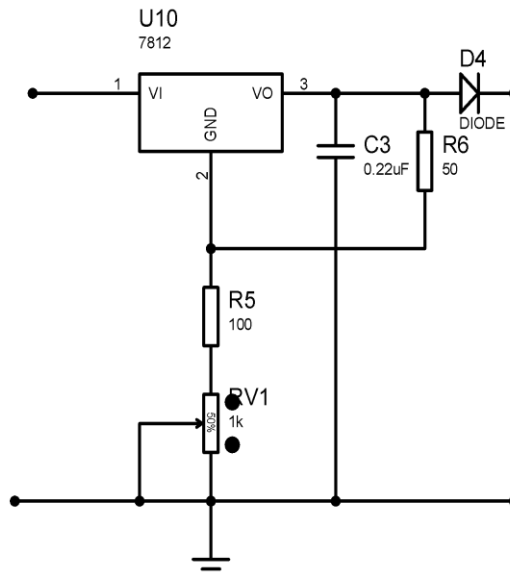


Figure 4. L7812 voltage regulator schematic diagram

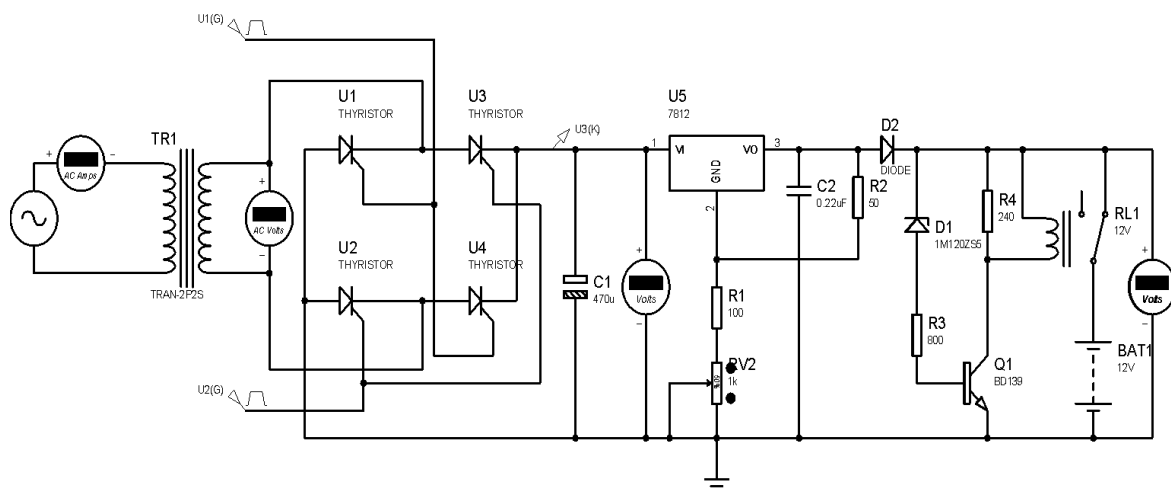


Figure 5. Schematic diagram of the overall electrical circuit

3.2. Electronic design

The electrical design is specially designed according to the design of the battery charger regulator. In the BCR circuit the components used are 4 thyristors BT151, ELCO, IC L7812, resistors, transistors, diodes, Zener, relays, and loads namely 12 V/5 A batteries. The application of BCR is to regulate the voltage for charging the battery to a power bank or uninterruptable power supply battery. BCR electronic design drawings can be seen in Figure 6.

Figure 6 is an electronic design of a battery charger controller that has been installed on a plywood and circuit board. Table 1 is the result of the thyristor test by entering an angle of 15 degrees to 180 degrees so that the output varies from 11 to 3.18 volts. Table 2 is the result of testing the transistor and relay with the result that the relay opens if the voltage reaches 13.45 volts. Table 3 above is the result of testing the IC regulator by providing variations in resistance to see the voltage regulated by the IC regulator. In this test the BCR circuit will be used to charge the UPS battery. In this case, we will pay attention to the source voltage across the thyristor and the voltage on the battery side and the battery charging current which are listed in Table 4.

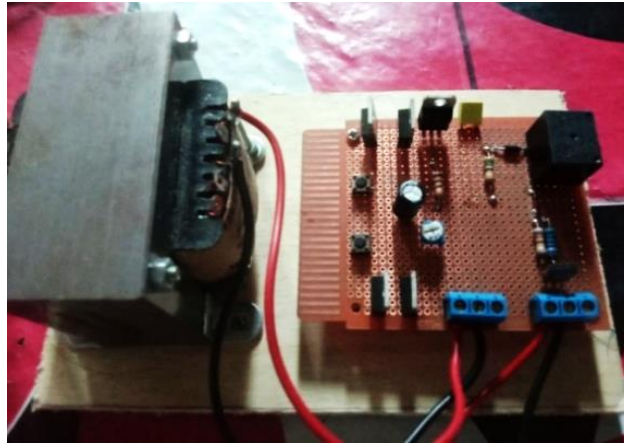


Figure 6. Electronic battery charger regulatory design

Table 1. Thyristor test results

No	Enter	Corner	Output V	Current
1	AC 15 V	15°	AC 11.22 V	0.1058 A
2	AC 15 V	30°	AC 10.45 V	0.1045 A
3	AC 15 V	45°	AC 10.10 V	0.1010 A
4	AC 15 V	90°	AC 8.71 V	0.0749 A
5	AC 15 V	180°	AC 3.18 V	0.0318 A

Table 2. Transistor and relay test results

No	Voltage	State relay
1	11.11 V	Close
2	11.56 V	Close
3	12.59 V	Close
4	13.45 V	Open

Table 3. L7812 regulatory IC test results

No	Resistor value	Voltage	Performance status system
1	20%	12.11 V	Good
2	40%	12.39 V	Good
3	60%	12.72 V	Good
4	70 %	12.90 V	Good
5	80%	13.45 V	Good

Table 4. Battery charging test results

No	Input voltage	Current	Battery voltage (DC)	Charging status	Time (minute)
1.	12.11 V	2.04 A	10.12 V	ON	0
2.	12.20 V	2.02 A	10.34 V	ON	60
3.	12.39 V	2.01 A	10.45 V	ON	120
4.	12.48 V	2.00 A	10.60 V	ON	180
5.	12.56 V	1.80 A	10.70 V	ON	240
6.	12.72 V	1.60 A	11.30 V	ON	300
7.	12.77 V	1.40 A	11.45 V	ON	360
8.	12.90 V	0.55 A	11.66 V	ON	420
9.	13.10 V	0.45 A	11.76 V	ON	480
10.	13.20 V	0.36 A	11.89 V	ON	540
11.	13.43 V	0.22 A	12.00 V	ON	600
12.	13.45 V	0.10 A	12.09 V	OFF	719

4. CONCLUSION

The conclusion of the research entitled battery charger regulator with full controlled rectifier 15 V/5 A on uninterruptible power supply has been successful and by the original purpose of being able to regulate the charging voltage and battery disconnection automatically. Charging may stop when the battery voltage reaches 13 volts. This value can change if we adjust the thyristor angle. Based on the results of testing the performance of the BCR system, the use of a fully controlled rectifier in the BCR system functions to convert AC voltage from a source (PLN) to DC whose output can be adjusted from 0-12 volts to become input for battery charging. Regulator IC 7812 regulates that the battery charging voltage does not exceed a predetermined limit.




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